In Vitro Comparison of Peak Polymerization Temperatures of 5 Provisional Restoration Resins

Caroline Lieu, B.Sc.N.
Tang-Minh Nguyen
Lise Payant, B.Sc., D.M.D., M.H.E.

Abstract

Background: The heat produced by provisional restoration materials may injure the dental pulp. This study measured and compared peak temperatures during polymerization of 5 materials used in the fabrication of provisional restorations.

Methods: The tested materials were 2 self-curing resins (Integrity and Protemp) and 3 dual-cure resins (Iso-Temp, TCB Dual Cure and Provipont DC). A mould the size of a maxillary molar tooth was fabricated to contain 0.5 cc of resin. The temperature rise of the different materials was recorded every 10 seconds over a 10-minute period.

Results: The rise in temperature of Integrity (peak temperature of 33.8°C) and Protemp Garant (35.6°C) was significantly higher than the rise in temperature of Iso-Temp (29.5°C), TCB Dual Cure (28.4°C) and Provipont DC (29.5°C).

Conclusion: Use of the dual-cure resins in provisional restorations may reduce the risk of pulp injury.

MeSH Key Words: crowns; dental pulp/injuries; resins, synthetic

© J Can Dent Assoc 2001; 67:36-9
This article has been peer reviewed.
Vallittu demonstrated that peak temperature increases were related to the amount of acrylic resin used and that the temperature could go as high as 82°C. Other studies compared temperature rise in pulp chamber during fabrication of provisional resinous restorations. Tjan and others tested the in vitro temperature rise in the pulp chamber induced by self-curing resins during the fabrication of provisional resin crowns using a direct technique. The results suggested the possibility of thermal damage to dental pulp and odontoblasts during the setting of provisional resins.

The purpose of this study was to measure and compare peak temperatures reached during polymerization of 5 different materials used in the fabrication of provisional restorations. The null hypothesis considered the 5 materials to be equivalent in terms of peak temperature reached.

**Materials and Methods**

Five bis-acryl resins were tested (Table 1). Two were self-curing resins (Integrity and Protemp Garant) and 3 were dual-cure resins (Iso-Temp, TCB Dual Cure and Provipont DC). Dual-cure resins contain bis-GMA composite and photo-initiators such as camphorquinone or benzoin methyl ether which give these resins their photopolymerization characteristics.

A mould approximately the size of a maxillary molar tooth was fabricated to contain about 0.5 cc of resin and to hold the tip of a thermometer (Fig. 1). The exterior of the mould was made from velmix and the inner part was lined with 2 mm of polyvinyl material (President microsystem, Coltene/Whaledent, Mahwah, New Jersey). The rise in temperature of the different materials was recorded every 10 seconds over a 10-minute period using a digital thermometer (Radio Shack, Inter-Tan Ltd, Canada) which read in 0.1°C increments. The measuring probe was calibrated to ensure its accuracy. A good thermal contact was always obtained between the probe and the tested material. Each material was tested 10 times. The mixed material, the mould and the probe were at room temperature when the test began. A cover lined with velmix–polyvinyl was always placed above the mould to minimize the heat loss of the tested materials.

A Bartlett statistics test was applied to determine homogeneity of variance of the results. The data for the peak temperatures were then subjected to a two-tailed analysis of variance test (ANOVA) to disclose statistically significant differences between groups (p < 0.05). Finally, a Tukey test for a posteriori comparison was used to determine the specific differences among the resins. The statistical software SAS was used to analyze the data.

**Results**

The mean temperature for each of the 5 resins recorded during a 10-minute period is presented in Figs. 2a to 2e. Table 2 lists the mean values of the maximum temperature elevations of the resins during polymerization. Protemp Garant had the highest mean temperature (35.6°C) while TCB Dual Cure had the lowest mean maximum temperature (28.4°C).

Homogeneity of variance was shown with the Bartlett test. Statistical analysis indicated significant differences among the resins tested in this study (Table 3); therefore, the null hypothesis, which stated that the peak temperatures of the 5

**Table 1 Provisional restoration resins tested**

<table>
<thead>
<tr>
<th>Product</th>
<th>Material type</th>
<th>Manufacturer</th>
<th>Ratio of mixing (gm of base to catalyst)</th>
<th>Batch No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iso-Temp</td>
<td>Dual cure</td>
<td>3M (St. Paul, MN)</td>
<td>10:1</td>
<td>19980206</td>
</tr>
<tr>
<td>TCB Dual Cure</td>
<td>Dual cure</td>
<td>Sci-Can (Pittsburgh, PA)</td>
<td>4:1</td>
<td>PC704949</td>
</tr>
<tr>
<td>Integrity</td>
<td>Self-cure</td>
<td>Dentsply Caulk (Milford, DE)</td>
<td>4:1</td>
<td>980515</td>
</tr>
<tr>
<td>Protemp Garant</td>
<td>Self-cure</td>
<td>ESPE (Norristown, PA)</td>
<td>4:1</td>
<td>B008 C068</td>
</tr>
<tr>
<td>Provipont DC</td>
<td>Dual cure</td>
<td>Ivoclar Vivident (Schaan, Liechtenstein)</td>
<td>4:1</td>
<td>926024</td>
</tr>
</tbody>
</table>

**Table 2 Mean maximum temperature reached during polymerization**

<table>
<thead>
<tr>
<th>Resins</th>
<th>Mean (°C)</th>
<th>SD</th>
<th>Error Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provipont DC</td>
<td>29.53</td>
<td>0.678</td>
<td>0.215</td>
</tr>
<tr>
<td>Integrity</td>
<td>33.75</td>
<td>1.113</td>
<td>0.352</td>
</tr>
<tr>
<td>Iso-Temp</td>
<td>29.47</td>
<td>0.389</td>
<td>0.123</td>
</tr>
<tr>
<td>Protemp Garant</td>
<td>35.63</td>
<td>1.269</td>
<td>0.401</td>
</tr>
<tr>
<td>TCB dual cure</td>
<td>28.42</td>
<td>1.037</td>
<td>0.328</td>
</tr>
</tbody>
</table>

SD = standard deviation
resins used in this experiment would be equal, was rejected. However, to determine the specific differences among the resins, Tukey’s test for a posteriori comparison was used. Peak temperatures of self-curing resins were found to be significantly different from peak temperatures of dual-cure resins ($\alpha = 0.05$). Tukey’s test showed that Integrity (33.8°C) and Protemp Garant (35.6°C) were statistically higher in terms of peak temperatures than Provipont DC (29.5°C), Iso-Temp (29.5°C) and TCB Dual Cure (28.4°C) ($p = 0.0001$). No significant differences were found among the peak temperatures of products within the same category.

Discussion

Castelnuevo and Tjan$^8$ reported that the bis-GMA resin had a lower rise in temperature than the bis-acryl composite. Since dual-cure resins contain a bis-GMA component, this may explain why we found that dual-cure resins released significantly less heat than self-curing resins. In this study, all 5 products tested produced a rise in temperature during polymerization. Specifically, the mean temperatures of self-curing resins at room temperature were significantly higher than that of the dual-cure resins. The self-curing resins produced a temperature increase of at least 5°C higher than the dual-cure resins. Considering that a rise of 10°F (5.6°C) in the temperature of the pulp can have a significant impact on the pulp,$^5$ a difference of 5°C between the 2 classes of resins can be a major factor in the extent of injury to the pulp.

A temporary restoration should protect the teeth while a permanent restoration is being made. Most dentists use a direct technique to fabricate provisional restorations because it
costs less and is more efficient. However, the effect of the exothermic release of resins should always be a consideration when making a temporary restoration, as the heat released might harm the surrounding oral tissues and the dental pulp. The advantage of dual-cure resins lies in their lesser temperature rise during polymerization compared to self-curing resins. However, all types of temporary resins exhibit exothermic reaction. It is therefore the responsibility of the dentist to be aware of all heat-producing materials and to minimize their potential injury to oral tissues. Using an indirect technique may be more time-consuming, but it permits better control of the heat released during polymerization. External cooling with air or water during intraoral polymerization can be used to avoid undue heating to the pulp. Removing the temporary crown from the prepared tooth prior to the complete curing stage is strongly recommended, although this may cause some deformations in the crown.

**Conclusion**

All 5 resins tested caused a rise in temperature during polymerization. The self-curing resins (Protemp Garant and Integrity) caused a significantly higher temperature rise during polymerization than the dual-cure resins (TCB Dual Cure, Iso-Temp and Provipont DC). There was no significant difference among peak temperatures of products within the same category. Using the dual-cure resins for the fabrication of provisional restorations may reduce the risk of pulp injury because of its lesser temperature rise compared to self-curing resins. Further investigations should focus on in vivo trials of these products and on their effect on the physiology of the pulp.

**References**


**Table 3**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Sum of square</th>
<th>DF</th>
<th>Mean square</th>
<th>f-test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provisional materials</td>
<td>395.096</td>
<td>4</td>
<td>98.774</td>
<td>108.88</td>
<td>0</td>
</tr>
<tr>
<td>Error (or residual)</td>
<td>40.824</td>
<td>45</td>
<td>0.9072</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected total</td>
<td>435.92</td>
<td>49</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

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Ms. Lieu is a student in the faculty of dentistry, Laval University.
Mr. Nguyen is a student in the faculty of dentistry, Laval University.
Dr. Payant is professor in the faculty of dentistry, Laval University.
Correspondence to: Dr. Lise Payant, Dental Faculty, Laval University, Quebec, QC C 1K 7P4. E-mail: lise.payant@fdm.ulaval.ca.
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